$C^{18}O$ and HDO in IMs

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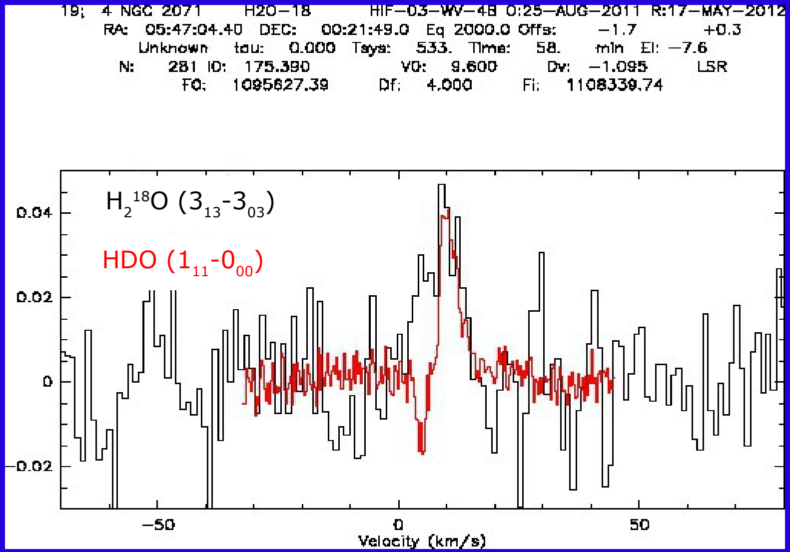
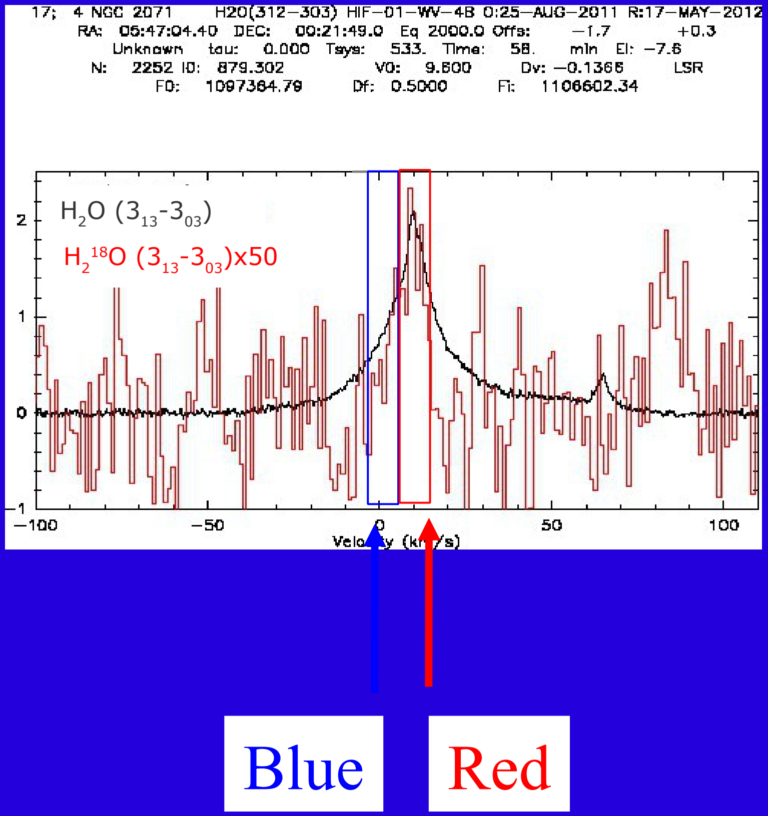
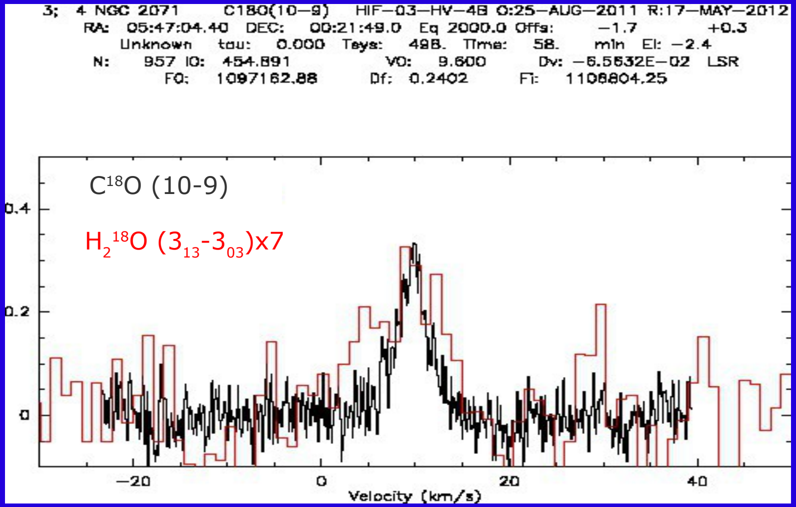
NGC 2071

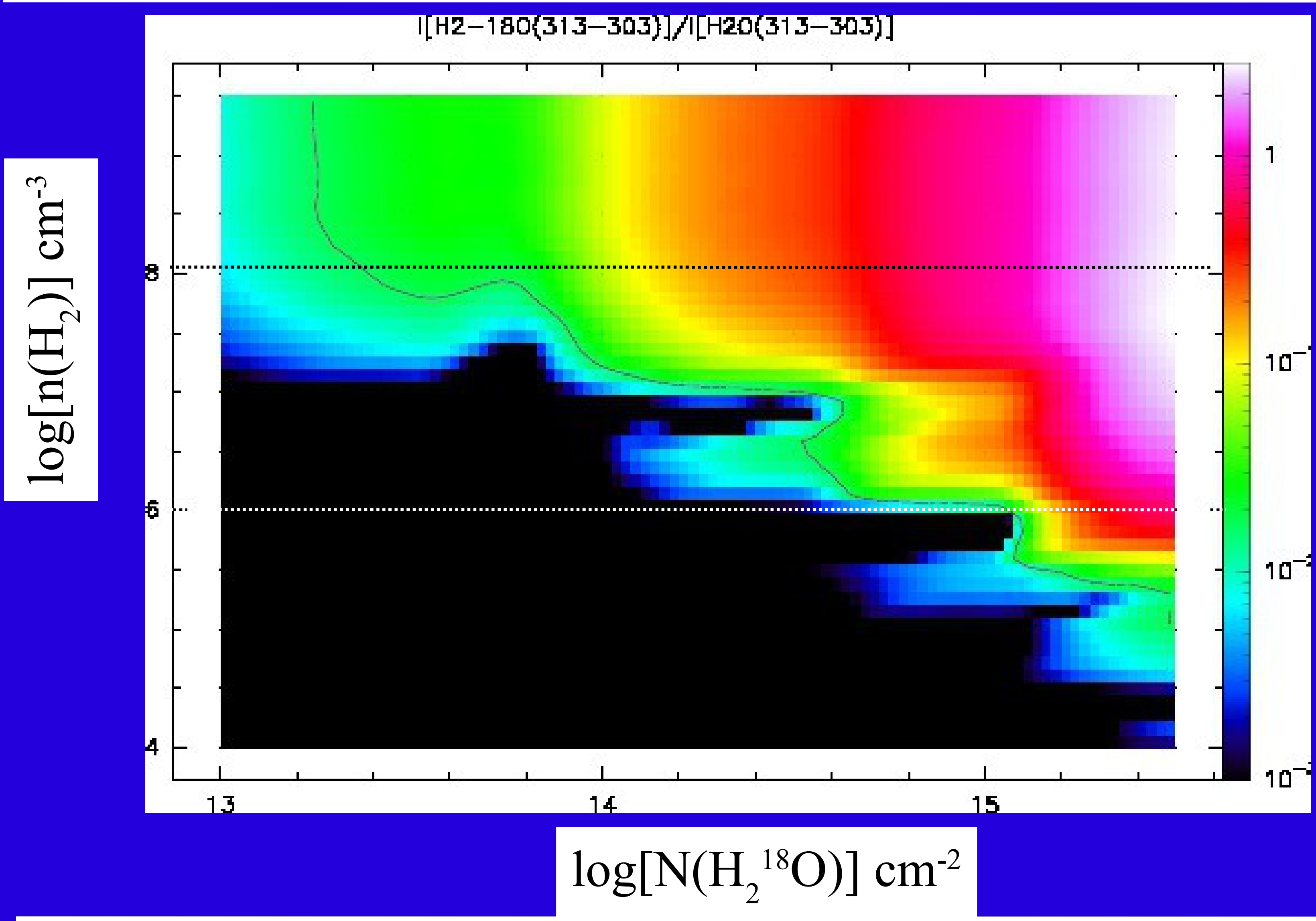






Different physical conditions blue/red

NGC 2071 (MADEX calculations)



NGC 2071

Table 2. Observational Parameters

	Blue	Red
$I(H_2O\ 3_{12}\text{-}3_{03})$ (K×km/s)	8.61	13.03
$I(C^{18}O\ 10\text{-}9)$ (K×km/s)	0.23	1.05
$I(H_2{}^{18}O\ 1_{11}\text{-}0_{00})$ (K×km/s)	0.14	0.22
$I(HDO\ 1_{11}\text{-}0_{00})$ (K×km/s)	-0.11	0.86
$I(H_2O)/I(H_2^{18}O)$	60	58
$I(H_2^{18}O/C^{18}O)$	0.6	0.2
$I(H_2^{18}O/HDO)$	...	0.3
$T_{mb}(H_2^{18}O)$ (K)	0.019	0.028
$T_{mb}(HDO)$ (K)	...	0.11
T_{mb} $(C^{18}O)$	0.03	0.13

Table 3. Summary of models

	$n(H_2)=10^8\ cm^{-3}$	$n(H_2)=10^6\ cm^{-3}$
size-blue	2.8"	2.9"
size-red	3.4"	3.5"
N(HDO) red	$5\times10^{14}\ cm^{-2}$	$2\times10^{16}\ cm^{-2}$
τ red	3.35	~200
$X(HDO)/X(H_2O)^*$ red	0.017	0.016
$N(C^{18}O)$ blue	$8\times10^{15}\ cm^{-2}$	$8.5\times10^{15}\ cm^{-2}$
$X(H_2O)^*$ blue	6×10^{-7}	2.5×10^{-5}
$N(C^{18}O)$ red	$2.6\times10^{16}\ cm^{-2}$	$2.7\times10^{16}\ cm^{-2}$
$X(H_2O)^*$ red	1.9×10^{-7}	7.9×10^{-6}

* Assuming $[H_2O]/[H_2^{18}O]=500$

- The $HDO/H_2{}^{18}O$ ratio is not dependent on the assumed molecular hydrogen density, BUT HDO IS OPTICALLY THICK (tau>100)!
- The $H_2{}^{18}O$ abundance is degenerate with the density. THE DETAILED STRUCTURE OF THE SOURCE IS NEEDED!

Monte Carlo Simulations

Warning: The source does not have spherical summetry. Only a tool to research the robustness of our results

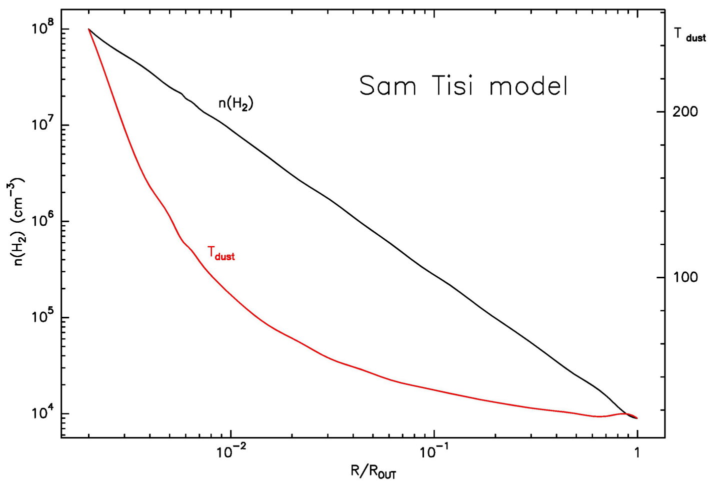
n-T profiles from Sam Tisi (we adopted the one with a density power law index of 1.5)

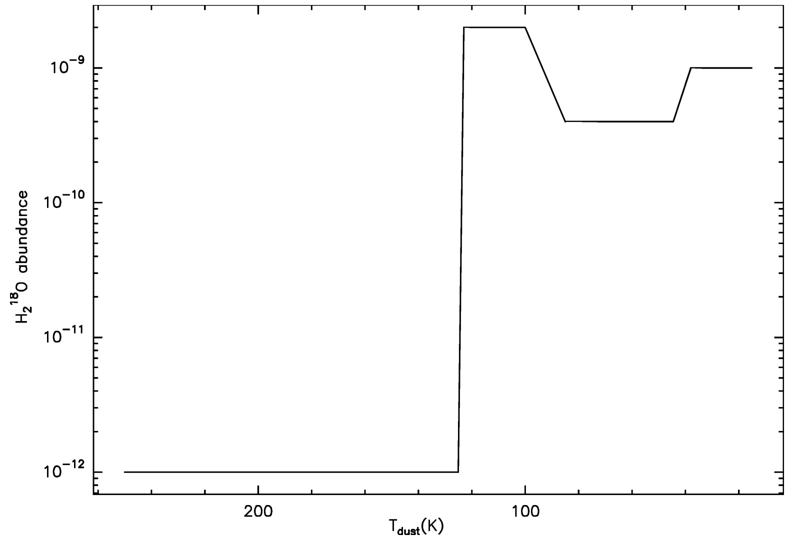
To mimick the outflow we assume an expanding envelope with the law

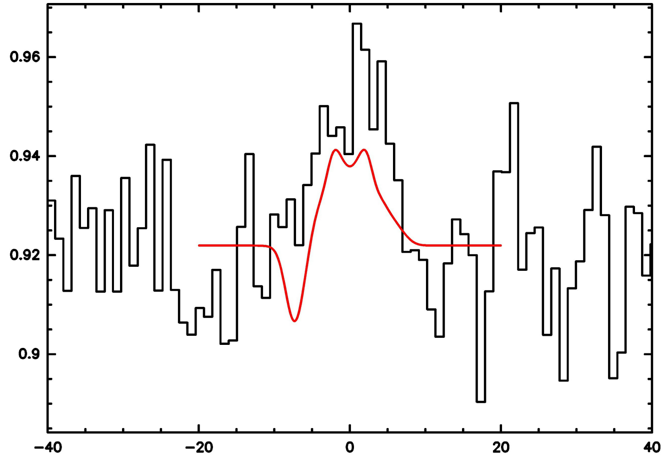
Vsource=8 km/s

Vexp=$(R/Rin)^{-0.4}$ km/s

Monte Carlo Simulations ($H_2^{18}O$)





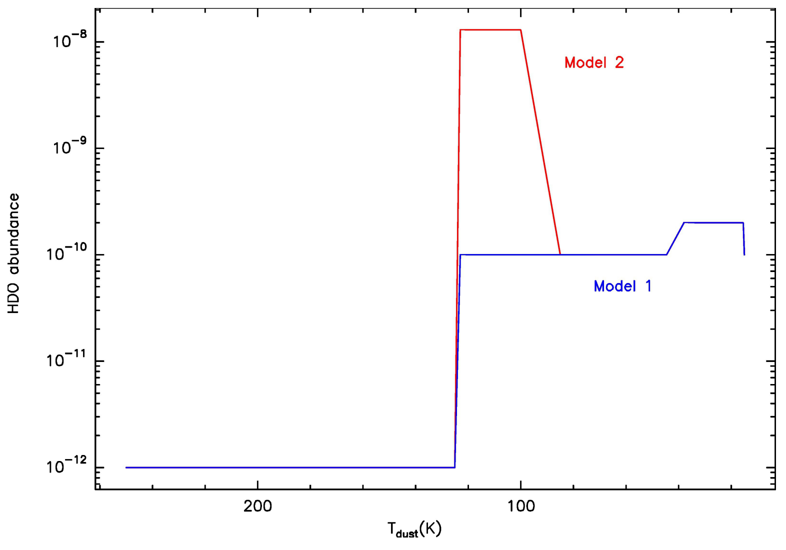


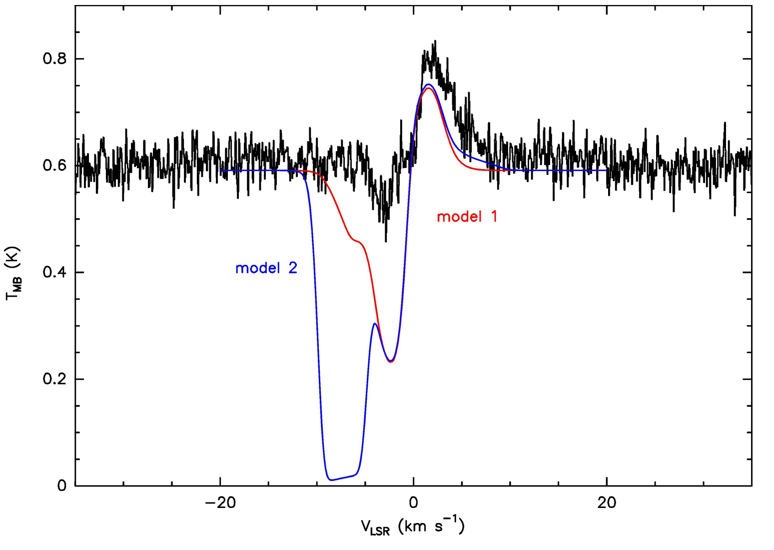
The fit is not good. A hole is assumed to avoid strong absorption.

$H_2^{18}O$ abundance= 2 10^{-9} for Tk>100 K

$H_2^{18}O$ abundance= 0.4 – 1 10^{-9} Tk<100 K

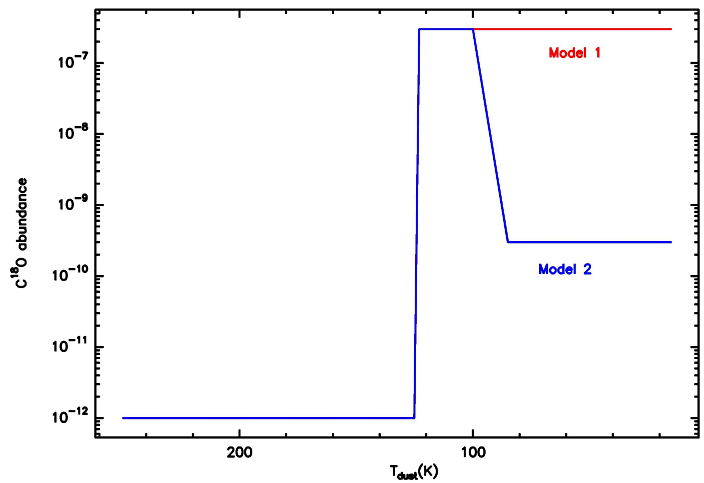
Monte Carlo Simulations (HDO)

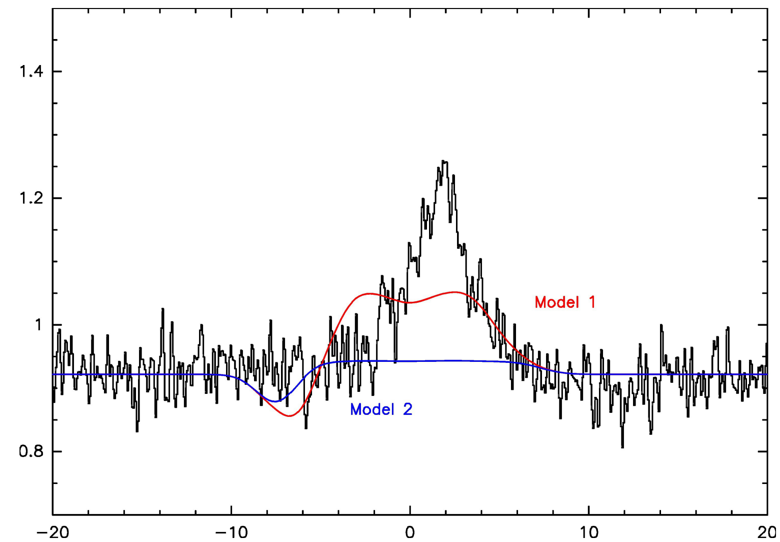




The HDO (1_{11}-0_{00}) emission at red velocities is not sensitive to the HDO abundance in the region Tk>100K. To increase this abundance, however, increase the absorption at blue velocities. For Tk<100K, the HDO abundance is around 1 – 2 10^{-10}

Monte Carlo Simulations ($C^{18}O$)





Bad fit assuming spherical symmetry.

- The best fit assuming a canonical $C^{18}O$ abundance of 3 10^{-7}
- >90% of the emission comes from the Tk < 100 K region.

Conclusions

Tk>100 K:

- $[H_2O] \sim 1.6\ 10^{-6}$
- $[HDO]/[H_2O] > 6\ 10^{-5}$

Tk<100 K:

- $[H_2O] \sim 3 - 8\ 10^{-7}$
- $[HDO]/[H_2O] = 3\ 10^{-4}$

The emission of the J=10->9 line of $C^{18}O$ is dominated by the region with Tk < 100 K.

Conclusions

The simple spherical model is not adequate for this source. For this reason, our conclusions are quite vague. We need higher excitation transitions of HDO and interferometric observations for a better undersanding.